



MICRO/NANO SENSORS FOR HEALTHCARE AND SMART CITY

By

Hong Kong Science and Technology Parks Corporation -
Electronics Cluster



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EXECUTIVE SUMMARY

The dawning of the Golden Age of microelectronics

At a time when businesses and consumers are increasingly looking to translate the physical world into digital format, small, durable and sophisticated sensors proliferate and play an expanding role in robotics, artificial intelligence, IoT, electronics and healthcare applications. Significant progress in Microelectromechanical Systems (MEMS) and Nanotechnology has enabled the manufacturing of a new generation of sensors, opening up a whole host of markets and opportunities yet to be fully explored.

Actively building a sensor R&D community at Hong Kong Science Park, Hong Kong Science and Technology Parks Corporation (HKSTP) organised the first International Symposium on Micro/Nano Sensors for Healthcare and Smart City with the IEEE Nanotechnology Council (NTC) on December 10, 2018 at Science Park. We brought in 12 internationally renowned experts from the US, Europe and Asia to talk about the latest developments in micro/nano sensor technology and to share their insights into applications in their specialist fields. It was also a forum for 300 leaders from industry, academia and the public sector to come together to exchange ideas and discuss issues raised by the speakers as well as wider trends and developments.

By the end of the conference, three broad themes had emerged. First, the market and commercial development opportunity for MEMS and nano-sensors is changing from consumer electronics to healthcare and smart city applications. There is no doubt that the coming years will be a "golden age" for microelectronics as a wide variety of advanced sensors will be needed for the rapid growth in healthcare and smart city applications.

Second, the biggest development trends relate to the development of sensors with new sensing materials, sensor device design and sensor fusion. Some more mature sensors, like Inertial Measurement Units (IMUs), will still have promising growth due to wearable and healthcare applications. Third, we see new devices coming that will have the potential to be used for the following applications: gas/environmental sensors, thermal imaging sensors, biosensors and microfluidics.

This paper provides a quick overview of sensor development at Science Park, followed by snapshots of the observations and insights of the invited speakers, grouped under four themes: Medical and Bio-tech, IOT and Location Base, Sensor Fusion and Integration, and Next-Gen Thermal Imaging. It also summarises the latest Research and Development work on sensor technology now underway at Science Park from the perspective of 10 partner companies based at the Park. Finally, this paper offers some direction for those interested in learning more about the conference content, the work of Science Park and ways to tap into the exciting new world of MEMS and sensor technology.

Mr. George Tee

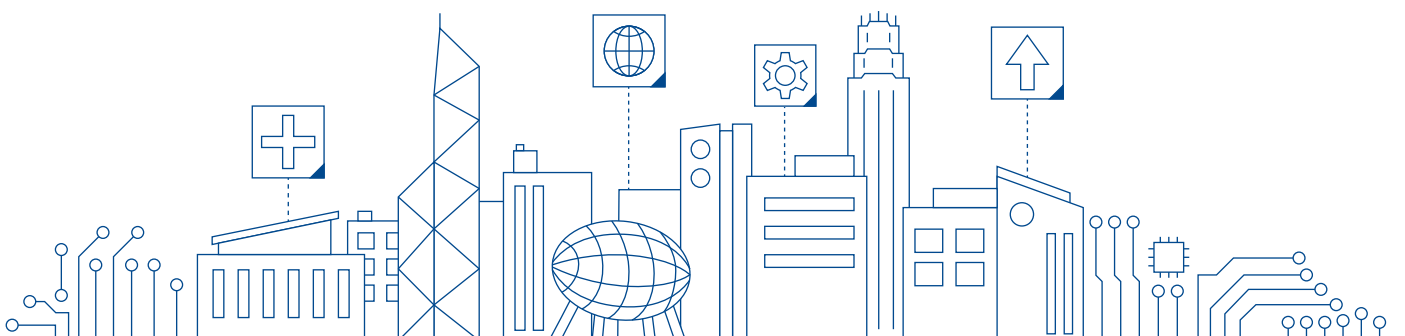
Chief Technology Officer

Hong Kong Science and Technology Parks Corporation

Ir. Peter Yeung

Head of EE & ICT Clusters, Smart City Platform

Hong Kong Science and Technology Parks Corporation



Sensor ecosystem thriving at Science Park

More than 700 technology companies were based at Hong Kong Science Park working on research and development in a range of fields including ICT, Electronics, Green Technology, Biomedical, Nanotechnology, Materials and Robotics. Mr. George Tee, Chief Technology Officer of HKSTP, told the symposium that the sensor ecosystem was growing rapidly at the park and the number of sensor-related companies had increased by 25% in the last year.

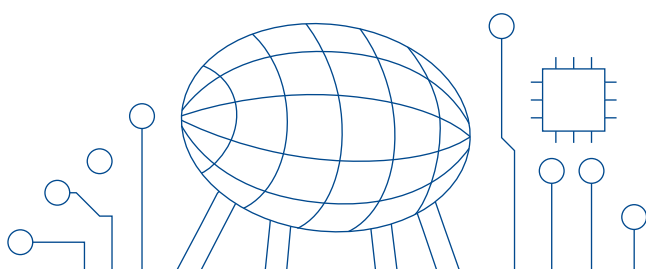
Mr. Tee said that Science Park was a Living Lab and uniquely positioned to help companies with sensor application testing. There was a dedicated Sensor Hub which welcomed academia, companies and industries to test sensor products, collect data and continuously fine-tune products. HKSTP had also set up a Sensor Lab in which R&D partners could work together to enable a platform for the design and development of sensor chips.

HKSTP was now building a sensor R&D community at Science Park bridging University researchers, R&D centres, leading technology companies, start-ups and investors to work on various upstream to midstream sensor-related research projects and applications. Mr. Tee said the community would be strengthened by the development of the Greater Bay Area and the Hong Kong Government's support for innovation and technology and the transformation of Hong Kong into a global I&T hub.

Science Park was a Living Lab and uniquely positioned to help companies with sensor application testing.



Mr. George Tee, Chief Technology Officer, Hong Kong Science and Technology Parks Corporation



Technology powered by the human body

Energy was the new era and self-powered nanogenerators were having a big impact on medical science, according to Professor Zhonglin Wang, the Hightower Chair in Materials Science and Engineering and Regents' Professor, of the Georgia Institute of Technology. Prof. Wang talked about the rapid development of nanogenerators based on triboelectric effects. He said that self-powered nanogenerators using triboelectrification (TENG) could be used for a host of medical science applications including:

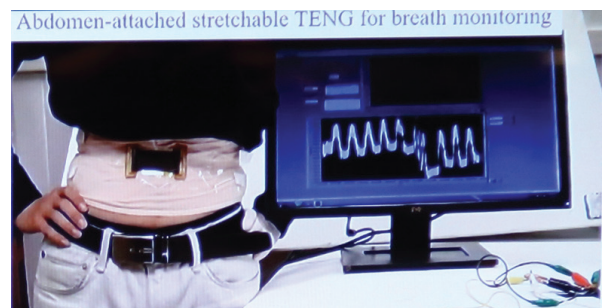
- wearable electronics powered only by human motion, realised through TENG with optimised materials and structural design;
- pacemakers powered by human breathing, enabled by TENG;
- monitoring of regular heartbeats and arrhythmia by ECG and TENG;
- wireless heart rate monitoring;
- implantable self-powered low-level laser cure system for mouse embryonic osteoblasts;
- self-powered throat microphones using a bionic membrane sensor offering superior anti-interference.

Prof. Wang concluded by summarising the likely trends from 2017 to 2027 for micro/nano power sources, self-powered sensing, blue energy and high voltage sources.

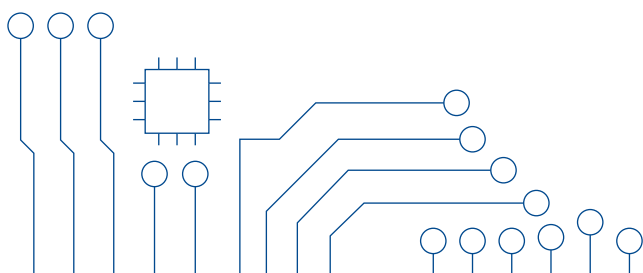
Self-powered nanogenerators using triboelectrification (TENG) could be used for a host of medical science applications.



(a) Prof. Zhonglin Wang, Hightower Chair in Materials Science and Engineering and Regents' Professor, Georgia Institute of Technology



(b) A stretchable-rubber triboelectric nanogenerator used as a self-powered body motion sensor (Source: Prof. Zhonglin Wang, Georgia Institute of Technology)



Micro bubbles bring relief for patients globally

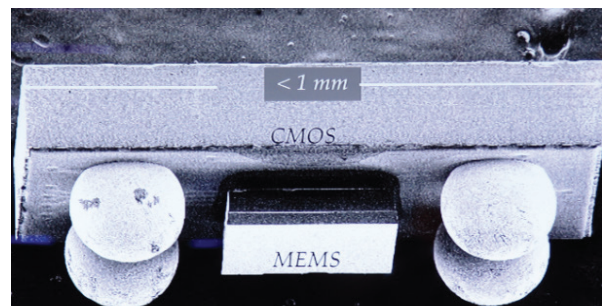
Micro bubble technology was emerging as a highly effective treatment for kidney stones. Thomas Kenny, Richard W. Weiland Professor and Senior Associate Dean for Student Affairs in the School of Engineering at Stanford University, referenced the new treatment as part of his presentation about advances in MEMS for IoT and Health. He said micro bubbles could be used to improve the safety and efficacy of the lithotripsy procedures. If the bubbles were introduced at the start and throughout the usual shockwave procedure, the kidney stones would be more rapidly broken down and the residual fragments would be smaller. The result should be faster procedures, less risk of damage to the patient, higher efficacy, less use of primary capital equipment and elimination of secondary treatments for at least one third of the 700,000 kidney stone patients each year.

Prof. Kenny said that size, power and cost would always be the key drivers for the development of MEMS in the future. In this presentation, he explained how the chip fabrication process on a single wafer and thick film encapsulation could enable the smallest possible MEMS for different sensors. He talked about the development of pressure sensors, gyroscopes, magnetometers and oscillators at Stanford University based on MEMS and film encapsulation. He also shared a story about the successful adoption of MEMS-based timing technology by a California-based company SiTime that was now at the core of almost all wearables and portable electronic devices.

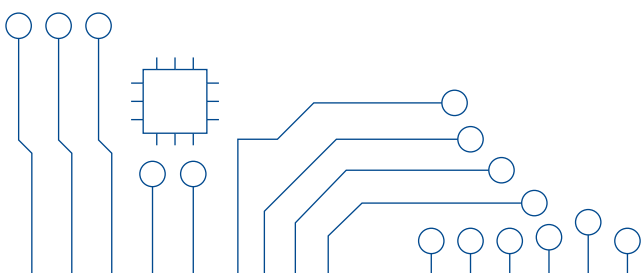
Micro bubbles could be used to improve the safety and efficacy of the lithotripsy procedures.



(a) Prof. Thomas Kenny, Department of Mechanical Engineering and Senior Associate Dean for Student Affairs, Stanford University



(b) Micrograph of MEMS and CMOS dies and final CSP package (1.5 x 0.8mm) (Source: Prof. Thomas Kenny, Stanford University)



MEMS is here to stay

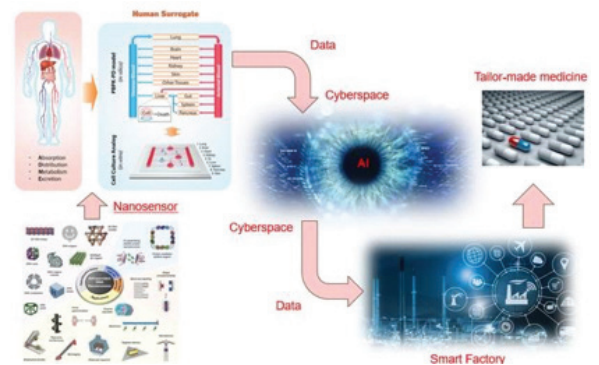
MEMS had become a fundamental and mature technology for sensors, said Professor Osamu Tabata of Kyoto University, and nanosensors were becoming important to AI and connecting things in cyberspace and the physical world. Prof. Tabata presented an overview of the development of micro and nano sensors from the past to the future, especially in Japan.

He touched on a range of emerging technologies including nanosensors, IoT, AI, deep learning, organs-on-chips and plasmonic materials. During his presentation, Prof. Tabata discussed the body on a chip and an AI concept for drug development, covering new therapies, precision medicine and safer clinical trials. He concluded MEMS would continue to expand and accelerate the development of new sensors to the benefit of society.

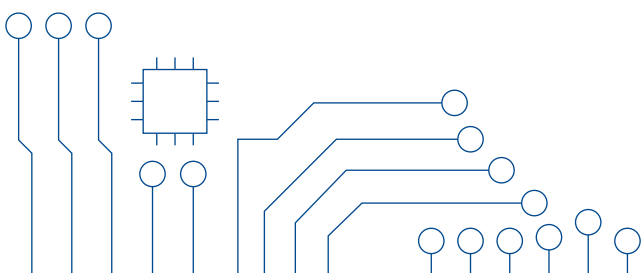
MEMS had become a fundamental and mature technology for sensors.



(a) Prof. Osamu Tabata of Kyoto University



(b) Positive outlook for the connection of nanosensors, IoT and AI through cyberspace (Source: Prof. Osamu Tabata of Kyoto University)



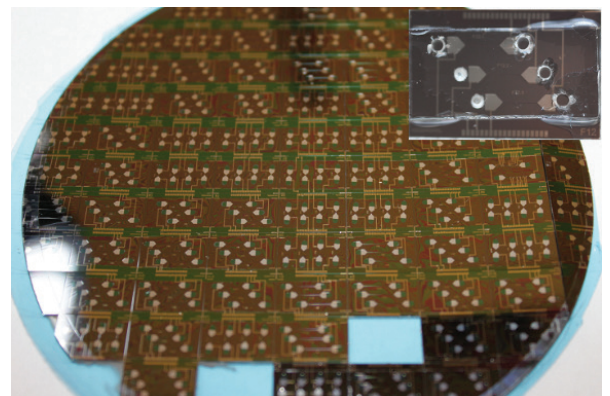
Using electrokinetics to detect biomolecules

Integrating electrokinetics in ion sensitive field-effect transistors (ISFETs) could result in a more reproducible and sensitive bio-sensing platform, Uppsala University's Dr. Apurba Dev, Researcher, Department of Solid State Electronics, The Ångström Laboratory, suggested in his presentation on silicon nanotechnology for biomolecule sensing and the Si-based multiplexed bio-sensing platform. During his presentation, Dr Dev introduced the electrokinetic effect for the detection of different large biomolecules with a better response signal and suggested that ISFET/BioFET could offer high sensitivity for detection of biomolecules. He highlighted the approach of sensing of DNA by solid state nanopores by using silicon process technology which involved the fabrication of large arrays using lithography.

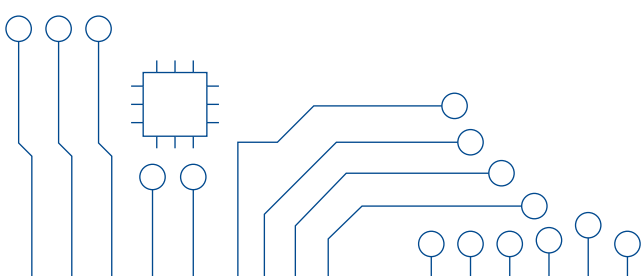
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(a) Dr. Apurba Dev, Researcher, Department of Solid State Electronics, The Ångström Laboratory, Uppsala University



(b) Wafer with chip layout and capillary channels with nanopores (Source: Dr. Apurba Dev, Uppsala University)



Sensors helping patients inside and out

Tracking the journey of a medical pill through the human body was just one of the valuable sensor applications shared by mCube, Inc.'s Chief Executive Officer, Mr. Ben Lee. Hong Kong Science Park-based mCube talked about the development of single chip MEMS and CMOS inertial sensors and systems for medical applications, including:

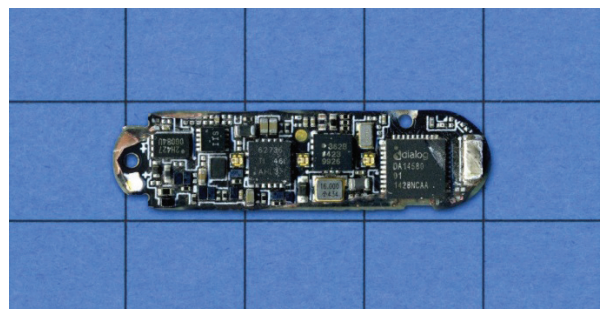
- inertial sensors to enable tracking of the location of medical pills in the body and to monitor pill activation as well as actuation of the medical function of pills with the embedded sensor electronics;
- wearable sensors to detect when its user has a fall and to send an alert transmission, as well as pre-fall data logging;
- inertial sensors enable robotic and autonomous devices in surgery;
- smart gloves using multiple accelerometers to aid therapeutic applications;
- accelerometer and gyroscope system to track motion trajectory.

Mr. Lee also highlighted the emerging motion sensor applications in wearables for changing behavior, such as sport performance enhancement and injury monitoring. mCube had just set up an application team at Science Park to support the development of various motion sensing applications.

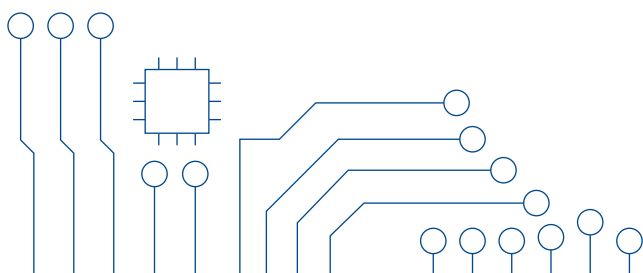
Wearable sensors can detect when its user has a fall and send an alert transmission and conduct pre-fall data logging.



(a) Mr. Ben Lee, Chief Executive Officer of mCube, Inc.



(b) A wearable device which can be embedded in clothing and equipment (Source: Mr. Ben Lee, mCube, Inc.)

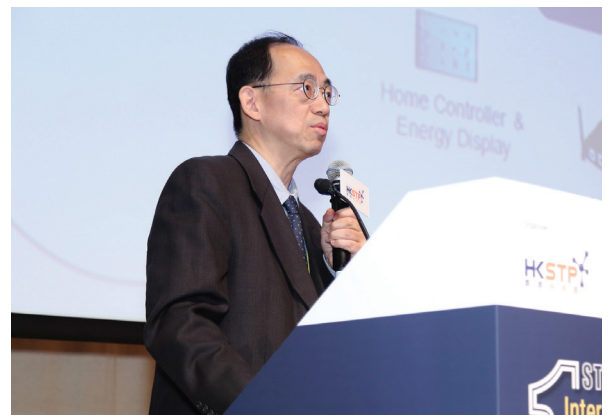


Enhancing semiconductors with MEMS

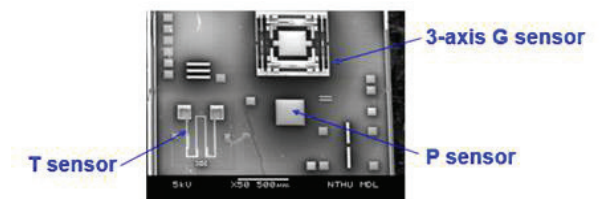
Semiconductors combined with MEMS and sensor technology were now the key to IoT, according to Professor Weileun Fang, of National Tsing Hua University. Prof. Fang highlighted that semiconductors were being enhanced by adding MEMS and sensor technology, miniaturised advanced packaging technology and ultra-low power technology. He shared the CMOS-MEMS platform for the fabrication of sensors, with its mature CMOS process, thin film etching and silicon etching. It could produce MEMS components and sensing circuits such as 3-axis G-sensors, pressure sensors, magnetic sensors and microphones. In addition, it was easy to integrate three sensors together for a tire-pressure monitoring system through monolithic sensor integration.

During his presentation, Prof. Fang also shared a poly-silicon platform for acoustics sensors, a metal-MEMS platform that used metal to fabricate vertical inductors and 3D TSV, and a polymer-MEMS platform using polymer to fabricate optical components. The platforms could form the building blocks of a microsystem, further reinforcing the role of MEMS as a key enabling technology for IoT in the future.

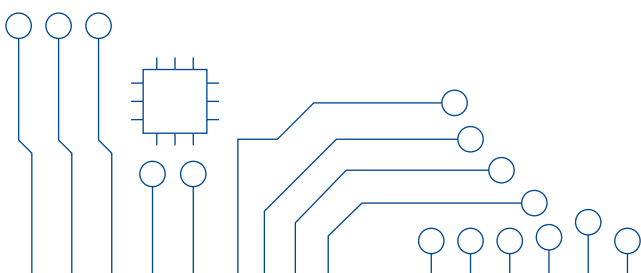
Semiconductors combined with MEMS and sensor technology were now the key to IoT.



(a) Prof. Weileun Fang of National Tsing Hua University



(b) Integration of G-sensors, temperature sensors and pressure sensors for the tire-pressure monitoring system
(Source: Prof. Weileun Fang, National Tsing Hua University)



Sensors driving advances in healthcare and the environment

High performance sensors were helping industry make giant strides in healthcare and environmental monitoring, using micro and nano-engineered devices. Professor Inkyu Park, of the Korea Advanced Institute of Science and Technology, talked about a wireless smart glove system for human motion detection and personalised health monitoring through the Internet of Things (IoT). It was made possible by using a nanocomposite of microstructured polymer (nanosphere) with conductive nanomaterials (metal nanowires) to produce wearable and flexible physical sensors. Furthermore, a multiplexed sensor array could be fixed on biomedical tools to enhance the accuracy and safety of clinical procedures such as a smart micro-sensor integrated needle for high precision biopsies.

Prof. Park also outlined the key requirements for the next generation of gas sensors which offered truly personalised environmental air quality monitoring through MEMS and Nanotechnology. He explained that the integration of sensing nanomaterials with microheating platforms could result in an ultra-low power and ultra-compact gas sensor array.

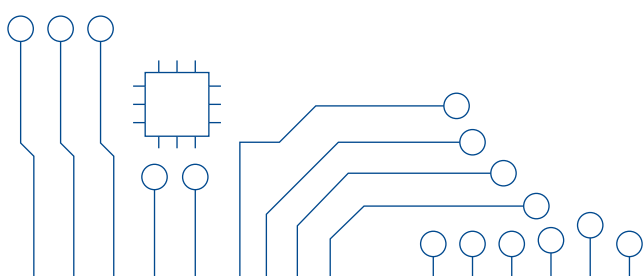
The integration of sensing nanomaterials with microheating platforms could result in an ultra-low power and ultra-compact gas sensor array.



(a) Prof. Inkyu Park of the Korea Advanced Institute of Science and Technology



(b) Wireless smart glove system for human motion detection (Source: Prof. Inkyu Park, Korea Advanced Institute of Science and Technology)



Tracking technology powering smart city development

Location information would continue to be a major driver for new retail and smart city development. Professor Gary Chan, of Hong Kong University of Science and Technology, noted that advances in 4G and 5G networks would greatly increase the location accuracy of users in the future. Prof. Chan said that research was now focusing on location sensing algorithms, sensor innovations, machine learning and data analytics. It could enable new location-based applications and services and create new and immense commercial and social value.

He also shared real applications of IoT sensors for anonymous or target tracking, which could be applied to monitor the movement of people in shopping malls, hospitals, smart carparks or theme parks. For example, wifi sensors were installed at Science Park for people sensing via the HKSTP Sensor Hub programme. The new fusion-based location sensing technology could reduce the position error to less than 2.5 metres in a general environment, which was three times more accurate than traditional approaches and could infer user trajectories without violating individual privacy.

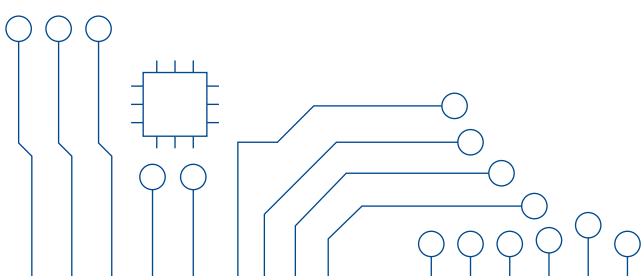
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(a) Prof. Gary Chan of Hong Kong University of Science and Technology



(b) A wifi sensor installed at the Atrium Link @ Hong Kong Science Park (Source: Prof. Gary Chan, HKUST)



System integration key to readouts

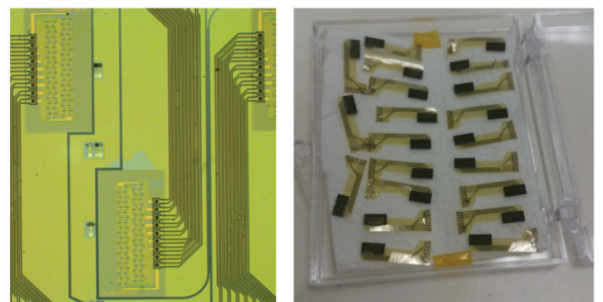
A novel magnetic sensing principle used for MEMS position readouts was showcased by Dr. Joao Gaspar, Head of Micro and Nanofabrication Department, International Iberian Nanotechnology Laboratory. Dr. Gaspar noted that a hybrid solution could provide devices with improved performance and new functionalities. He emphasised that system integration was the key for spintronics and MEMS technologies and offered the following examples:

- an accelerometer of reduced size with a magnetic readout;
- magnetic sensors with improved signal-to-noise ratio in the DC/low-frequency range;
- simplified MEMS packaging procedure to help integrate magnetic sensors on flexible devices.

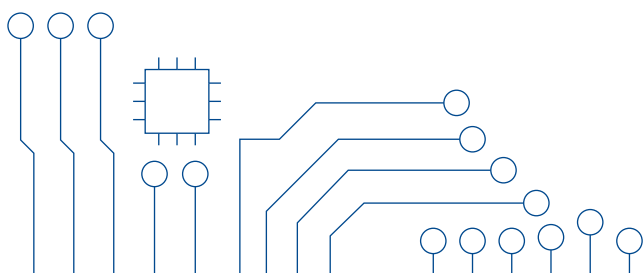
System integration was the key for spintronics and MEMS technologies.



(a) Dr. Joao Gaspar, Head of Micro and Nanofabrication Department, International Iberian Nanotechnology Laboratory



(b) Magnetic devices with flexible interconnects (Source: Dr. Joao Gaspar, International Iberian Nanotechnology Laboratory)



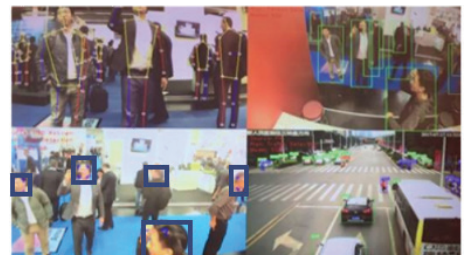
Sensors leveraging machine learning

Technology company Xilinx, a leading supplier of programmable logic devices, introduced machine learning and sensor fusion solutions. Mr. George Wang, Senior Staff Digital Signal Processing (DSP) Specialist at Xilinx showed a demo of a real-life embedded vision system based on deep learning, computer vision and sensor fusion. Various sensing capabilities using face sensor, gesture sensor, traffic single shot detector (SSD) and pedestrian SSD – were shown on one single social device. Mr. Wang said Xilinx could provide configurable and scalable AI devices which offered high performance, low power demand and low end-to-end latency.

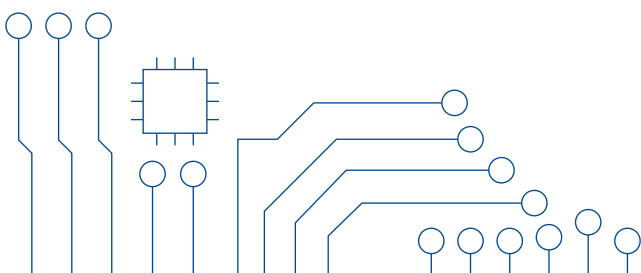
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(a) Mr. George Wang, Senior Staff Digital Signal Processing Specialist, Xilinx



(b) Real-time demo of multiple sensors and networks based on machine learning and Xilinx's platform (Source: Mr. George Wang, Xilinx)



Thermal imaging driving better lifestyles

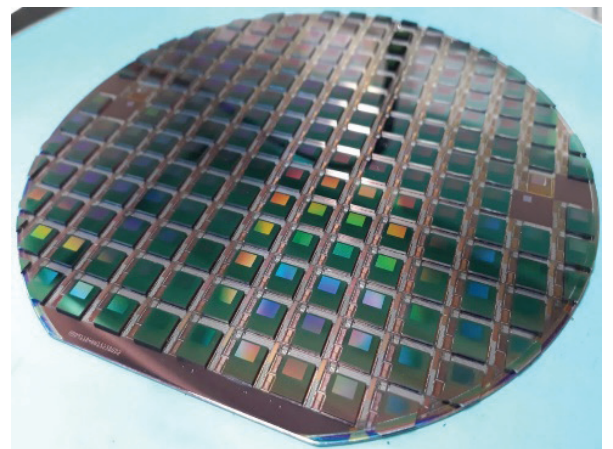
Thermal imaging sensors were powering a range of applications, such as autonomous driving, which could enable better and safer lifestyles, according to the co-founder of Meridian Innovation Limited, Mr. Hasan Gadjali. Based at Hong Kong Science Park under its Incubation Programme, Meridian is a HKSTP Sensor Lab partner using the park's lab facilities to prototype CMOS hybrid imaging sensors using a proprietary wafer level vacuum packaging process.

Mr. Gadjali said the advantages of thermal imaging sensors were that there were no privacy issues and that no self-heating or shutters were needed during the sensing application. Therefore the CMOS hybrid thermal imaging sensor could be used for a wide range of applications including motion sensing, autonomous driving, surveillance, intelligent sensing for home appliances and IoT.

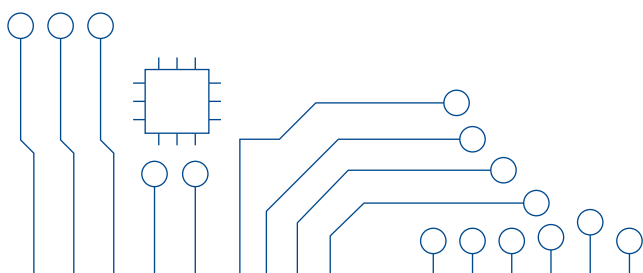
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(a) Mr. Hasan Gadjali, co-founder of Meridian Innovation Limited



(b) Bonded wafer based on advanced wafer level vacuum package at Hong Kong Science Park's Sensor Lab (Source: Mr. Hasan Gadjali, Meridian Innovation Limited)



SNAPSHOT OF THE LATEST SENSOR R&D AT SCIENCE PARK

Ten Science Park partner companies were asked to describe their work and innovative processes and to give examples of the industries and sectors that were most likely to benefit from their sensor products and solutions. Here's what they had to say.

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AAC Acoustic Technologies

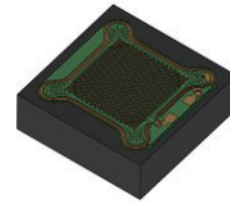
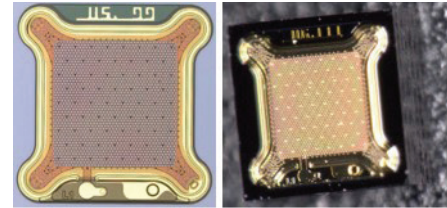
AAC Acoustic Technologies (AAC) is researching, developing and manufacturing leading edge solutions to enhance the user experience of smart mobile devices. AAC's product lines can be found in smartphones and portable electronic devices across the world. Cutting-edge technology, fast responses and high-precision manufacturing have made AAC a partner of choice for many OEMs and ODMs. AAC cooperates with partners to create differentiated and innovative products in both global and local markets.

AAC's MEMS chip team is more focused on deep research in advanced structure design and semiconductor technologies. It provides products and solutions in many areas, such as sensors, acoustics, haptics and optics. AAC offers a total solution for mobile phone design and performance, including a multi-mode digital microphone, full-screen acoustics and haptics solution.

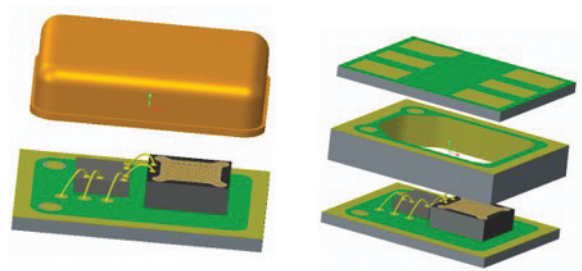
For the multi-mode digital microphone, for instance, the MEMS team provides high signal to noise ratio (SNR), high acoustic overload point (AOP), narrow tolerance and multi-mode. As a result, the device will have a better voice signal, noise cancellation and a strong anti-interference capability.

AAC's full-screen acoustics comes with several advantages. It offers improved looks and easier water-proofing and dust-proofing due to the absence of an opening for the receiver. Meanwhile, the voice quality is as good as a normal receiver with low distortion and bass satisfying speech requirements. Sound is generated from the screen surface, making it convenient to hold without sacrificing sound performance.

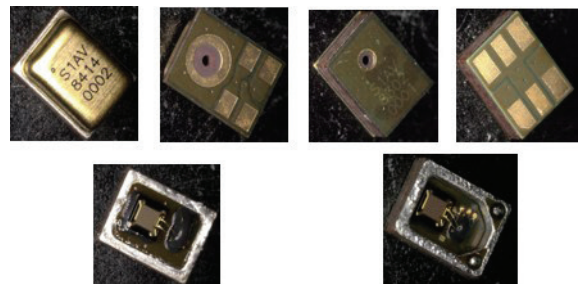
The haptics solution provides user interaction through the touch screen or side sensors with high performance customisable haptic feedback, which synchronises with the audio and visual effects to give a striking immersive experience.



MEMS Chip



Own design



Production

(Source: AAC Acoustic Technologies Limited)

Future Impact Lab

Future Impact Lab specialises in IoT and AI solutions for the retail and smart building industries, as well as driving digital transformation. The company provides different R&D services ranging from software and hardware to algorithms and design. For software, the R&D services include web, apps, WeChat and other cloud-based applications. For hardware, it includes electronic circuits and embedded systems. And for algorithm and design, it includes camera-based AI, IoT signal processing, e-health, smart living, UX-and business-driven design.

The battery-driven, real-time data generated by the IoT system can be applied to environmental sensing systems, to monitor water, air and soil quality. Other applications include e-health for tracking body temperature and blood pressure and utility for energy metering.

For the AI system using camera and other data sources, the technology can be used across several industry sectors such as retail, e-health and building. For retail, it can help enhance cost-effectiveness through unmanned stores and add value through customer loyalty and tracking programmes. The AI system also offers predictive maintenance for the building sector and smart farming capabilities to help communities and the environment.



(Source: Future Impact Lab Limited)

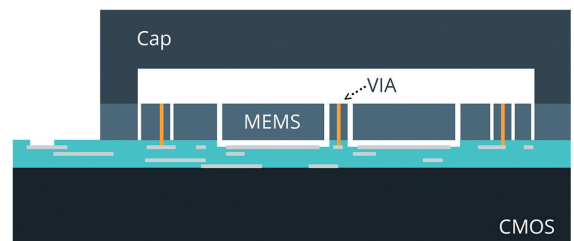
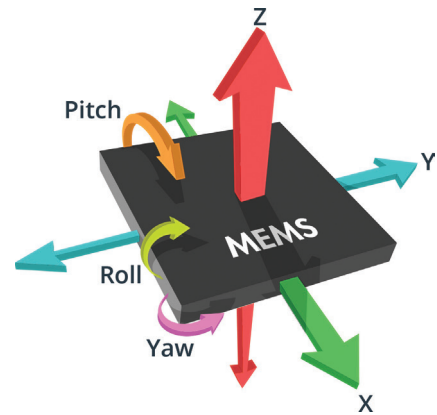
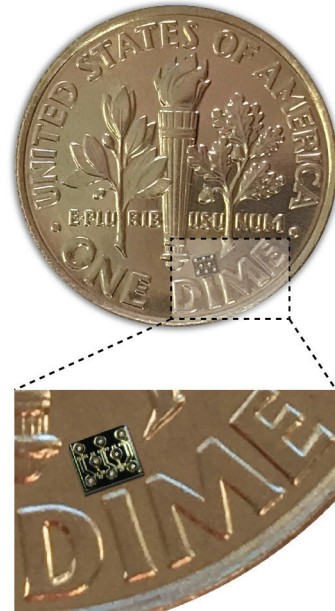
mCube Hong Kong

mCube provides the world's smallest MEMS motion sensors, key enablers for the new Internet of Moving Things (IoMT). Virtually anything that moves can take advantage of a motion sensor, creating a huge market opportunity for MEMS manufacturers.

By 2020, analysts predict that more than 50 billion devices will be connected to the Internet and a large percentage of them will be in motion. From smartphones to tablets, from gaming devices to augmented reality experiences, from smart clothes to wearables, a plethora of new applications are coming to market that will further transform the way consumers live and businesses operate. To connect anything that moves to the Internet and to monitor, analyse and deliver real-time insights from the data requires a new approach to MEMS inertial motion sensors.

mCube's monolithic, single-chip technology represents the next generation of sensors – very small, single-chip MEMS+ASIC devices that are cost effective, consume low power and feature high performance. These advances make it possible to place one or more motion sensors onto nearly any object or device. In some cases, these MEMS motion sensors can be embedded directly into a device without requiring a package, which saves considerable cost and real estate.

As the first company to integrate a MEMS sensor with ASICs onto a single die using standard CMOS processes, mCube is delivering this next generation of sensors by making them simple to manufacture and easy to design into a broad range of applications.



mCube's monolithic, single-chip design approach represents the next generation of sensors - very small, single-chip MEMS+ASIC devices that are low power, high performance and cost effective.

(Source: mCube Hong Kong Limited)

Meridian Innovation

Meridian Innovation provides thermal imaging sensors and solutions for safer and better living. Meridian's approach is unique, technically innovative and scalable in providing cost effective solutions to the mass market. Legacy thermal imaging cameras have been around for a long time but they are very expensive and difficult to be mass produced. They are priced out of the reach of consumers and are unsuitable for new AI applications. Meridian's CMOS process solution is cost effective and can be produced in high volume to meet the needs of consumers and new AI applications.

Meridian's patented CMOS hybrid thermal sensing architecture and advanced proprietary Wafer Level Vacuum Packaging (WLVP) combines the benefits of Thermopile and Microbolometer technologies. The advantages of patented CMOS hybrid thermal sensing architecture are:

- Smaller pixel size than conventional thermopile;
- Scalable to high volume production;
- Easy calibration;
- Low power consumption;
- Low cost CMOS;
- Miniature Wafer Level Vacuum Package (WLVP);
- No self-heating and no shutter required.



(Source: Meridian Innovation Limited)

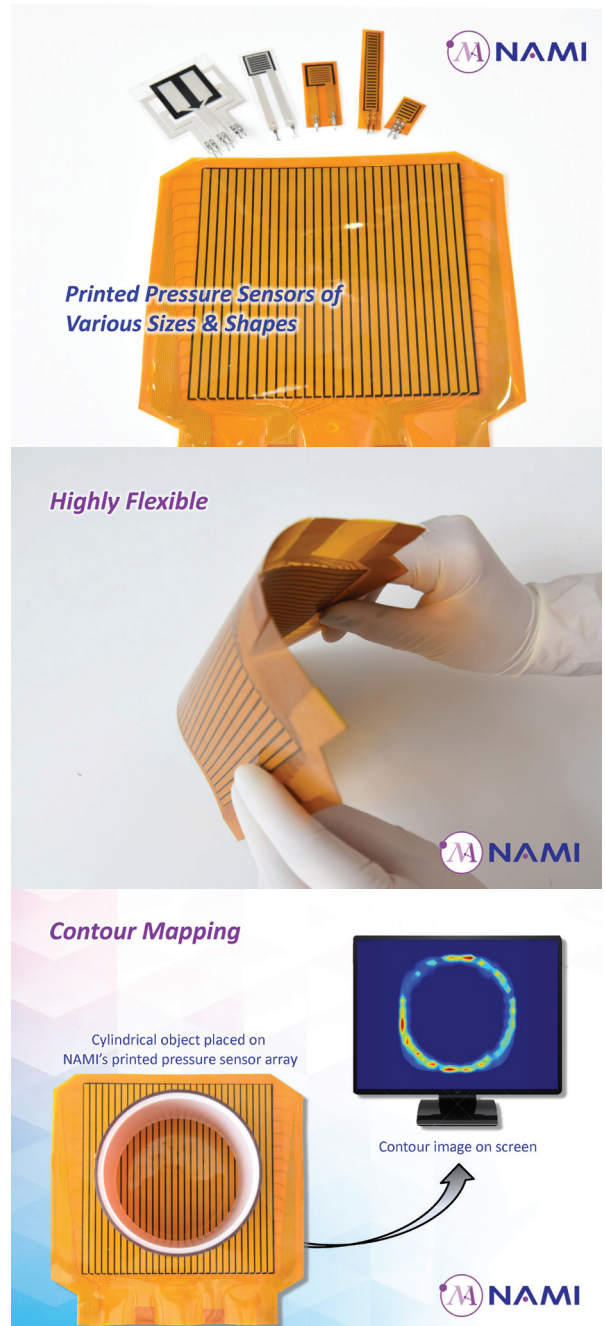
Nano and Advanced Materials Institute

Nano and Advanced Materials Institute (NAMI) was incorporated in 2006 and designated by the Hong Kong Government as an R&D centre for nanotechnology and advanced materials. It strives for the commercialisation of technologies to promote the growth of Hong Kong as a knowledge-based economy. NAMI's platform technologies in electronics include printed sensors, thermal technology, photochemical and quantum-dots, eMuscle auto-fitting material, as well as battery technology.

While wearable and light-weight electronics are becoming more desirable in human life, traditional tactile sensors tended to be rigid, coming in fixed sizes and shapes. So NAMI engineered a flexible sensor which could be easily integrated with many products to continuously monitor pressure. It used a proprietary composite material sandwiched between two flexible substrates, with electrodes printed on each substrate. The sensing material is formulated in such a way that a thin film can be easily formed by a mature and economical method of screen printing.

Because of the thin film architecture, the sensor or sensor array is also flexible and bendable. Products could be designed as single sensor to check pressure at a specific location or as a sensor array to monitor pressure distribution over a large area. The technology affords a seamless transfer from the lab scale to the printing industry for high volume production. As a result, end users can enjoy a high performance pressure sensor at affordable cost.

NAMI's printed sensor and array technology for pressure monitoring was named the Innovation Awards Honoree at the Consumer Electronics Show 2019. It provides a versatile and easy to integrate technology for medical devices, consumer electronics, sports, educational toys and many IoT applications such as smart home, smart bed and smart chair.



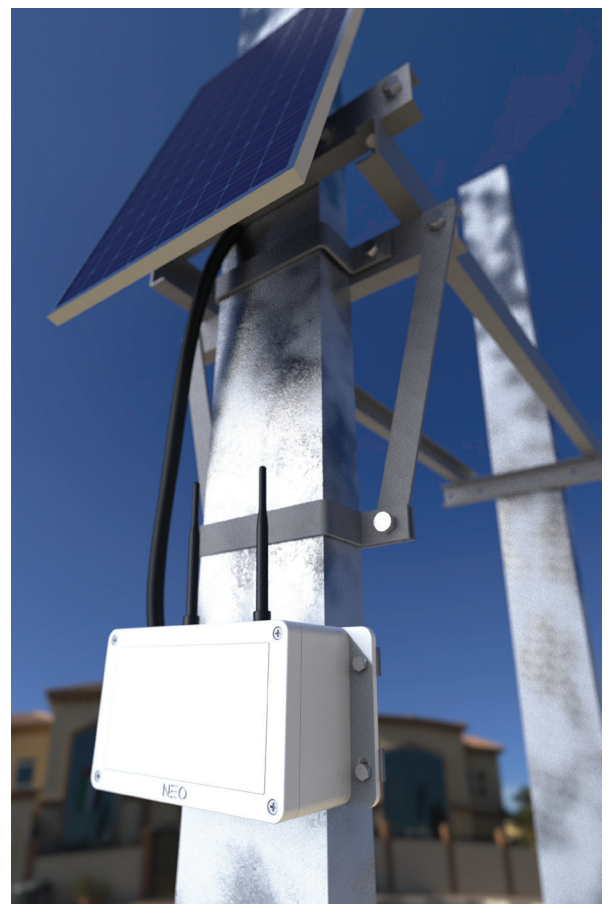
(Source: Nano and Advanced Materials Institute Limited)

Neosen Energy

Neosen Energy specialises in wireless power, solar renewable energy transformation and LoRa hardware development. It also offers long-range, low energy consuming asset tracking solutions using its self-developed trilateration algorithm and embedded sensing transceivers. They provide a tracking solution for everything from cattle animals and airline bags to nursing home and hospital patients, construction site workers, office staff and university students.

One product, NeoSmart, is a long-range, low-cost tracking solution with a range of 7 km. It involves a customised tracking device, such as an animal tracking tag, patient wristband or luggage tag, and a simple hardware installation that costs less than a smartphone. Users can track their assets' location anytime and anywhere, and the system will issue an alert if an asset leaves the boundary that is programmed in the app. NeoSmart uses low power radio communication and triangulation to locate the position of assets without GPS.

SafeKard is the world's thinnest card case with an NFC reader and LoRa transmitter. SafeKard reads and transmits the RFID information from the user's ID card when a HELP button is pressed. It can locate the user's position via a proprietary trilateration so that assistance can be rendered.



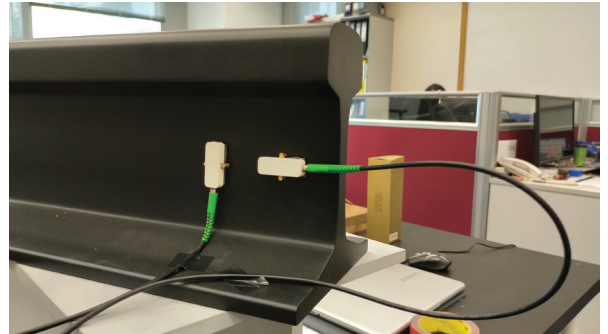
(Source: Neosen Energy HK Limited)

Optical Sensing

Optical Sensing focuses on the research, development, design and implementation of smart city infrastructure and utility systems including power networks, reinforced structures and transportation. It uses the most stable and maintenance-free sensing devices to acquire data about the infrastructure and systems – fibre optic sensors. Fibre optic sensing is based on changes in light patterns related to changes in temperature, strain, vibration and sound.

Optical Sensing provides complete solutions to monitor power distribution networks, cooling systems and structures. The company developed advanced techniques to analyse vast amounts of data to determine the operational health intelligence of the target infrastructure. The smart solutions enable asset owners to implement effective preventive maintenance procedures to protect their valuable assets and enhance service integrity.

The sensor technology can apply to building facilities such as fire risk detection, strain sensing and water pipeline leak detection. The DTS fire detection system is highly reliable as the fibre sensor does not require power and triggers an alarm based on incremental changes in the temperature gradient as well as absolute temperature readings.

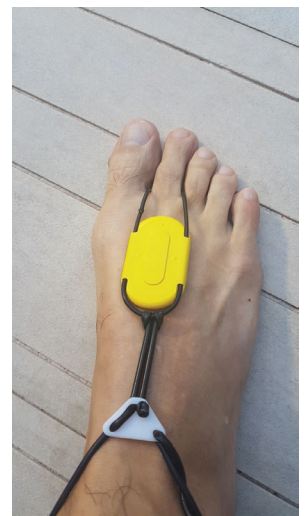
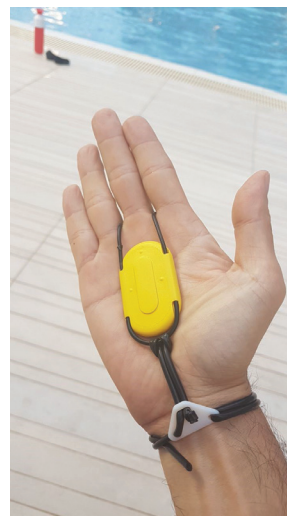


(Source: Optical Sensing Limited)

Platysens

Platysens develops wearables with motion sensors and force sensors to capture motions in different sports. While the MEMS sensors used are widely available, the combination of the algorithms and device design allows for accurate measurement of data critical for each sport. The sensors are customised for specific sports and the devices are calibrated to measure data relevant to the specific sports applications.

The first products from the company are targeted at watersports such as swimming and rowing. For example, the Marlin is a head-mounted device that uses motion sensors to recognise swimming performance metrics such as laps and stroke rate and reports the result in real time to the swimmer. The device also has a variant for use in rowing which captures the motion of a crew and provides feedback. Another swimming related product is the Seal, which is a system of sensors that measures force and motion to help swimmers identify weaknesses in their swimming strokes. The combination of force with motion data is relevant to different parts of swimming training. Similar technology can be applied to a variety of different sports.



(Source: Platysens Limited)

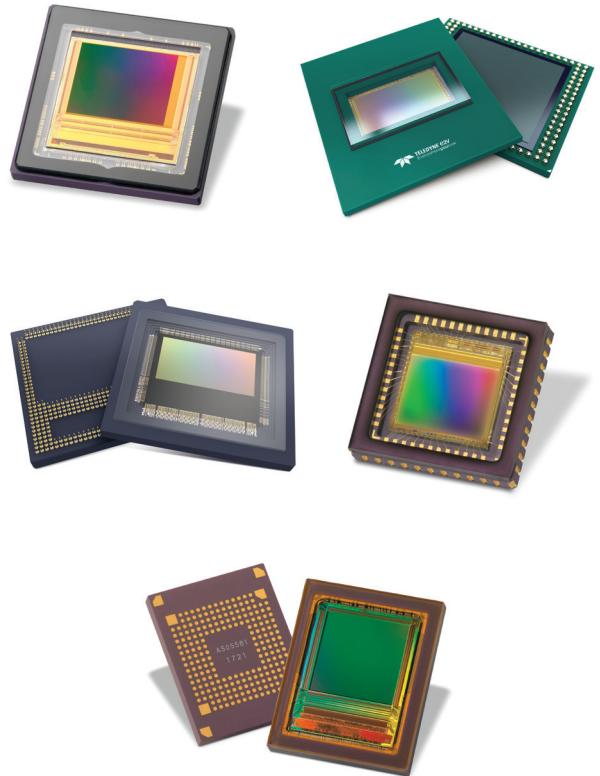
Teledyne e2v Asia Pacific

Teledyne e2v Asia Pacific has more than 40 years' experience in imaging and close to 20 years in CMOS image sensor development. Having a full internal assembly and test capability, and supported by experienced engineers, Teledyne provides innovative standardised or customised imaging solutions that bring increased value to customers' systems.

The company produces a range of sensors related to filters, linear sensors, 2D, 3D and different output interfaces. It has even implemented on-chip specific algorithms for market-leading customers. Teledyne is inspired by listening to market leaders. From a technical point of view, its sensors always embed an element of innovation such as a smaller global shutter pixel or a high pixel rate with low power consumption.

Teledyne has been actively developing solutions for 3D imaging, covering multiple industry applications, from laser triangulation to cobot (collaborative robot) applications. For industrial robots, the machines require a wide field of sight to detect small objects in order to manipulate them in a typical production chain. For occupancy detection, where people and machines coexist, it is necessary to detect people in a medium range with maximum accuracy. This type of application is the perfect example of how a 3D sensor is the ideal complement to a smart factory in terms of security.

Automated guided vehicles are most often used in industrial applications to transport heavy materials around a large industrial building, such as a factory or warehouse. 3D solutions are based on radio, camera or laser navigation technologies. Another interesting application of 3D vision is the profiling of objects in a high-speed production line which requires precise scanning to detect any defect in real time.



(Source: Teledyne e2v Asia Pacific Limited)

Well Being Digital

Well Being Digital (WBD) is the only Asian startup that has developed extremely accurate heart rate measurement technology, known as ActivHearts™, using Photoplethysmography (PPG) that can be used via earphones and attachments to the skin such as wrist watches or forehead, chest and arm bands. The patented OpticalFusion™ sensor array design uses multiple LEDs and photodiodes to ensure that very accurate PPG signals are collected from the skin even if the user is moving vigorously.

The subsequent digitised PPG data is passed through the ActivHearts algorithm that is contained in WBD's SmartBody™ Processor. The algorithm ensures that the PPG signals convert to accurate physiological signals like a dynamic heart rate when compared to the industry standard such as a chest belt using ECG.

By removing motion noise via OpticalFusion instead of using an accelerometer to calculate the displacement between the sensor and the skin, WBD preserves very detailed information that can be used to compute other physiological information. WBD's technology has been tested with different ear shapes, gender and skin colours, gathering useful data that can improve consumers' physical well-being through a wide range of exercises.

The OpticalFusion technology captures very accurate physiological signals such as dynamic heart rate, interbeat intervals (RRI) and motion so that the results can be useful for sports, healthcare and even medical applications. Earphone brands using OpticalFusion technology can have the sensors small and inconspicuous, as well as carte blanche on their designs without requiring any external modification of product surface.



(Source: Well Being Digital Limited)

ACKNOWLEDGEMENTS

Micro/Nano Sensors for Healthcare and Smart City

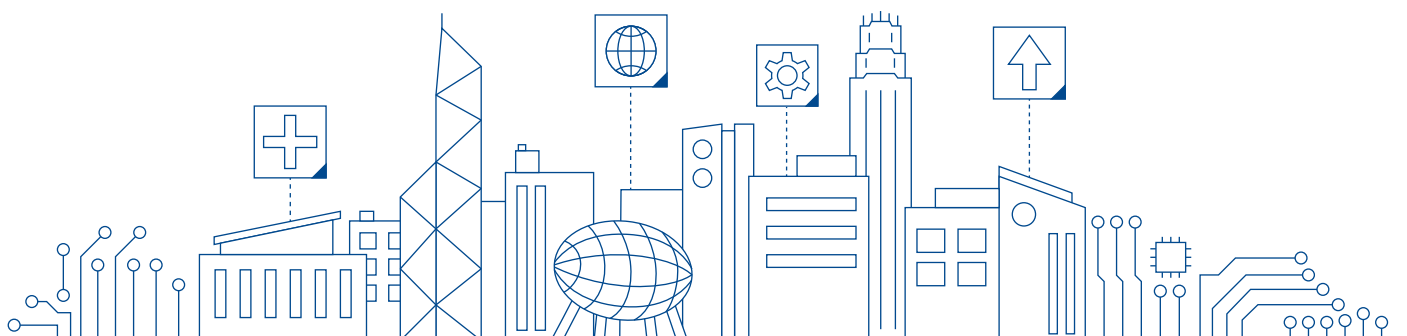
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